GAS OPERATING SYSTEM FOR FIREARM SIMULATORS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to United States Provisional Patent Application No. 60/402,464, filed on August 9, 2002.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to firearm simulators.

Description of the Prior Art

[0003] Because of the lethal characteristics inherent in operating guns, proper training in their use is imperative. Such training often involves the firing of blanks or live ammunition. Load noise, spent cartridge waste, noxious burned powder odors, repetitive reloading, environmental constraints, high cost and overall danger are all substantial detriments to the use of blanks or live ammunition.

[0004] To overcome the above disadvantages, training devices have evolved for simulating the firing of guns. These devices relate to weaponry having primarily military use. U.S. Pat. No. 4,302,190 discloses a rifle recoil simulator whereby compressed air passes through orifices in the rifle barrel to force the barrel upward in a recoil motion. A trigger switch activates an electronic timer-solenoid-air valve system for controlling air passage to the barrel orifices.

[0005] Artillery loading and recoil simulators are described in U.S. Pat. Nos. 4,194,304 and 4,365,959. These are complex mechanisms designed to train entire gunnery crews. They are not directly related to firearm recoil, which is the subject of the present invention.

[0006] To improve the realism of the weapons familiarization process and to provide a more "lifelike" experience, a variety of approaches have been suggested to make the weapons range more realistic. For example, some weapons ranges provide paper targets with

threatening images rather than bull's-eye targets. In attempts to present a more realistic scenario to the participant and to provide an interactive and immersive experience, some weapons ranges have replaced such fixed targets with moving or "pop-up" targets such as spring-loaded mechanical images or animated video images projected onto a display screen. The pop-up or animated images present moving targets and/or simulated return threats toward which the participant fires. One problem with such an approach is that the bullets damage or destroy the target. For example, the bullets can punch holes through display screens, eventually rendering the screens inoperative. Further, use of live ammunition can be very dangerous, especially in unfamiliar training exercises where the participant's performance limits are tested.

[0007] To address such problems, some training ranges use non-lethal ammunition, such as projectiles propelled by air cartridges in place of conventional bullets. One type of non-lethal ammunition is a Crown Type E air cartridge. In conventional uses of such cartridges, a releasable cap attaches to the cartridge and covers an outlet port. Then, when the outlet port is opened, a highly pressurized gas is released from the cartridge and propels the releasable cap away from the cartridge at a high velocity. The cap travels through a gun barrel and is emitted from the gun as a non-lethal projectile. To detect the impact locations of the non-lethal projectile, some such ranges use some type of projectile tracking device, such as high-speed imaging equipment. Such ranges can be very expensive due to their complexity and use of specialized equipment.

[0008] Other ranges allow the non-lethal ammunition to penetrate or otherwise mark a target object to indicate impact location. Such ranges have the drawback that the non-lethal ammunition is destructive. Additionally, the impact locations are difficult to track on a "real-time" basis, which makes interactive ranges difficult. Also, while such approaches may improve visual approximations of actual situations as compared to paper targets, such

approaches lack a visual or other virtually instantaneous feedback indicating the effectiveness of the participant's fire.

[0009] Another alternative type of weapons range employs a light beam in place of a projectile. In such ranges, the participant holds a simulated weapon shaped like a conventional weapon that is activated by a switch coupled to a conventionally shaped and positioned trigger. When the participant pulls the trigger, the simulated weapon emits a light beam that strikes the target, causing an illuminated spot. An optical detector detects the spot and indicates the impact location.

[0010] Such simulated weapons lack a realistic feel because they do not recoil in response to the simulated fire. Moreover, the simulated weapons do not emit shells that can distract the participant and can affect the participant's footing.

[0011] To try to simulate an actual weapon's recoil, a compressed air line can be coupled to the simulated weapon. Then, when the trigger is pulled, an air driven mechanism applies a pulse of force to the simulated weapon to produce a simulated recoil. Such a system has the drawback that the air line acts as a tether, limiting the participant's mobility and affecting aim. The system also lacks the ejected shells of actual or non-lethal ammunition.

[0012] The prior art attempts, including those described in U.S. Pat. Nos. 5,947,738 5,569,085, 4,480,999, and 4,678,437, to simulate recoil have limitations and drawbacks as discussed above in addition to being tethered to a console, lack of proper feel and balance, and related problems, all of which are solved by the present invention.

BRIEF SUMMARY OF THE INVENTION

[0013] The present invention is a firearm simulator that contains all of the necessary gas energy to operate itself and yet is electrically controlled and completely self-contained within the profile of the original weapon and with no lines or hoses protruding. The self-contained gas system allows for full simulator function and student mobility combined with computer

control of the weapon. Computer control is desirable to achieve a higher level of realism, to provide more training functions than a strictly mechanical simulator and to allow for remote communication and control.

[0014] In addition, the gas supply is housed within a simulated, removable magazine and is replenished by changing the magazine to a new one in the same fashion as is done on a live weapon. Thus, the student is trained to correctly reload the weapon by changing magazines. The gas in the magazine can be quickly recharged while the magazine is not being used in the weapon.

[0015] Also, the weapon simulator is not required to use explosives/flammables or to expel any solid material including cartridges or projectiles in order to create its cycling and recoil. This makes the weapon trainer safer, easier to use and allows for a more reliable function. Without projectiles, the weapon barrel may contain a laser device for purposes of providing weapon aiming information.

[0016] Furthermore, the weapon simulator includes one recoil valve to produce the desired recoil to mimic an actual firearm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Figure 1 is a sectional side view of one embodiment of the weapon simulator having a controlled gas operating system of the present invention;

[0018] Figure 2 is a sectional side view of another embodiment of the weapon simulator having a controlled gas operating system of the present invention;

[0019] Figure 3 is a sectional side view of the weapon simulator illustrated in Figure 2 with the weapon simulator having been discharged; and

[0020] Figure 4 is a sectional view of the recoil valve taken from lines 4-4 of Figure 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] Referring to Figure 1, one embodiment of the present invention of a firearm or weapon simulator **10** is illustrated. The weapon simulator **10** incorporates the use of an internal, regulated gas system **12** that is used to cycle the weapon simulator **10** and provide recoil in the weapon simulator **10** for the user. The gas system **12** is present in a removable magazine **14** that is contained entirely within the weapon simulator **10** and requires no external hoses, wires or connections of any kind. The use of this gas system **12** can be incorporated into various firearm designs, such as auto-loading rifles and pistols.

[0022] The magazine **14** of the present invention may be easily inserted and removed from the weapon simulator **10**, and contains the gas supply that is needed to operate the weapon simulator **10**. More precisely, the gas supply is contained in a built-in primary gas chamber **16** in the removable magazine **14**. The high-pressure gas supply allows storage of sufficient energy to power the recoil for the simulated weapon simulator **10** in correlation with the number of shots normally fired from a conventional, fully-loaded live magazine in a live weapon.

[0023] The high-pressure gas supply is reduced to a medium pressure in the present invention using a built-in regulator chamber **18** located in the magazine **14**. The regulator chamber **18** is connected to the primary gas chamber **16** via a narrow gas conduit **17**. The medium gas pressure from the regulator chamber **18** thereby allows the use of miniaturized electric valves **20**, **22** in the weapon simulator **10**; that is, the safe supply of gas to the electric valves **20, 22** is through various small gas ports **24**. There are two electric valves **20, 22** in the preferred embodiment: a recoil valve **20** and a locking valve **22**. Each valve **20, 22** is powered from an electrical supply (such as a battery) that may be contained within the weapon simulator **10**. The electric valves **20, 22** are turned on or off to deliver gas to a recoil cylinder/piston assembly **28** and a locking cylinder/piston assembly **30**.

[0024] The recoil cylinder/piston assembly **28** includes a piston that is used to drive a slide **32** or bolt of the weapon simulator **10**. The slide **32** is driven in a direction to accomplish all of the following: cycle the weapon simulator **10**, function a hammer/trigger mechanism **34**, and produce recoil in the weapon simulator **10**. The locking cylinder/piston assembly **30** includes a piston that is used as a binding mechanism to lock the slide **32** (or bolt) back when the weapon ammunition condition is simulated empty. That is, the locking cylinder/piston assembly **30** extends the piston as directed by the locking valve **22** to prevent the movement of the slide **32** after the weapon simulator **10** has fired a predetermined number of rounds.

[0025] A quick-connect fitting **36** with flow shut-off is used to connect the gas from the magazine **14** to the weapon simulator **10** internally and allows for removal and insertion of the magazine **14** in a similar manner as the live weapon at any time. A second quick-connect fitting **38** with flow shut-off is used for filling the magazine gas chamber **14**. The gas supply in gas chamber **14** is thereby recharged by removing the magazine **12** from the weapon simulator **10** and momentarily connecting it to a commercially-available high-pressure compressed-gas tank or vessel (not illustrated).

[0026] As discussed above, there are numerous firearm simulator trainers available on the market today. Many law enforcement, military and government agencies use weapon simulators to train their people. These trainers simulate the operation of a live weapon for the purpose of teaching the student to operate the weapon and to learn to use it against intended targets under various situations and conditions without the danger, effort, and expense of using live ammunition. To simulate the operation of a weapon design that is auto-loading and contains a moving bolt or slide assembly, a gas system is often employed. This system is used to drive the bolt or slide rearward to cycle the weapon as is similar in a live weapon. Weapon recoil is also simulated by nature of the bolt/slide being driven back toward the rear

against a recoil spring and often impacted against a part of the weapon. These forces push the weapon against the body of the shooter to provide a recoil force. Most of the auto-loading weapon designs being simulated also contain a removable magazine which holds a supply of ammunition for the weapon to fire. This feature is often included in weapon simulators to provide training for weapon reloading, immediate action drills for weapon jamming, and related situations. The gas systems currently and typically used in these types of simulators are summarized as follows.

[0027] A first common type of gas system uses low-pressure, 80-200 psi gas. This gas is supplied by an externally regulated, commercially available high-pressure compressed gas tank or by a source which actually compresses the low-pressure gas on site. One of the limitations of this system is that it requires a hose or line running from the weapon to a tank or compressor while the weapon is in use. The hose detracts from the mobility of the weapon/shooter because it is attached to a fixed, compressed gas supply or bulky portable compressed gas tank. The realism of the simulator is reduced because the hose protrudes from the weapon, which detracts from the look and feel of a live weapon. Another limitation is that the low-pressure typically requires large valves, cylinders and air passages to provide sufficient flow and area to produce the forces required to cycle the weapon and produce recoil. In the case of a pistol, the valves must be located external to the weapon which adds bulk and further detracts from the realism of the simulator.

[0028] A second type of gas system uses cartridges which contain high-pressure compressed gas. These cartridges are triggered by being struck with the weapon firing pin and they cycle the weapon with their rapid expansion and/or by gas expulsion which may also propel a projectile. The cartridges are loaded into the weapon magazine, chambered, fired, extracted and ejected in similar fashion to the live weapon. The cartridges are designed to be re-usable. The outside profile of the simulator is the same as the live weapon. The

limitations to this system are numerous. These include the high cost of the individual rounds which also wear out and can be damaged. The fact that each round must be individually charged and loaded into the gun magazine is very tedious and time-consuming to the user. The fact that the rounds are ejected exposes them to damage when stepped on and requires that they be individually collected. The fact that the cartridges occupy the magazine and must follow a path through the weapon removes much needed space for electronics and sensors in more advanced simulators. The fact that the simulated weapon must chamber, fire, extract and eject a cartridge for each shot in a similar manner as the original weapon and with much less energy causes the simulator to be less reliable than other types of firearm simulators.

[0029] A third type of gas system uses cartridges which contain an explosive/propellant. These cartridges are triggered by being struck with the weapon firing pin and they cycle the weapon with their rapid expansion and/or by gas expulsion which may also propel a projectile. The cartridges are designed to be disposable. The outside profile of the simulator is the same as the live weapon. The cartridges are loaded into the weapon magazine, chambered, fired, extracted and ejected in similar fashion to the live weapon. There are several limitations to this system. The fact that shells must be individually loaded into the magazine is time-consuming to the user. The fact that the expelled rounds lie on the floor/ground and must be collected and discarded is messy and causes additional work to the user. The fact that the cartridges occupy the magazine and must follow a path through the weapon removes much-needed space for electronics and sensors in more advanced simulators. The fact that the simulated weapon must chamber, fire, extract and eject a cartridge for each shot in a similar manner as the original weapon and with much less energy causes the simulator to be less reliable than other types of firearm simulators.

[0030] The present invention solves all of the limitations of the above-mentioned systems. Comparing the present design with the other gas systems described above, it is clear to see the limitations eliminated by the present invention. For example, comparing the present invention to the first gas system described above, the gas system **12** of the present invention is completely contained within the weapon simulator **10**. By storing compressed gas within the magazine **14** that is also at high-pressure, there is sufficient amount of gas energy within the weapon simulator **10** to cycle the weapon simulator **10**. The high-pressure gas can be used safely in the weapon simulator **10** through electric valve control because it is reduced in pressure through a regulator system also internal to the weapon simulator **10**. Thus, no hoses or external connections to the weapon are needed or used. In addition, because the weapon simulator **10** operates at a medium gas pressure which is higher than the existing low-pressure systems, the electric valves **20**, **22**, cylinders and air passages can be miniaturized. Thus, the electric valves **20**, **22** can be contained within the weapon simulator **10** by careful design, even in the case of when the weapon simulator **10** is a small firearm, such as a pistol or the like.

[0031] Comparing the present invention to the second gas system described above, various limitations of the previous system are solved by the present invention. Since the present compressed gas system **12** does not use cartridges that would have to cycle through the weapon simulator **10**, there are no cartridges to purchase, wear out, or damage. Recharging of the gas system **12** occurs only once for each time that a real weapon magazine would be reloaded. Since magazines **14** can typically hold from eight to thirty cartridges, this saves numerous rechargings per magazine **14** used. That is, the present invention does not require consistent recharging of the plurality of cartridges. In addition, no cartridges need to be loaded into the magazine **14** for proper operation. Therefore, this weapon simulator **10** is much easier to use. A related benefit is that there are no cartridges to collect from the

ground/floor and no rounds are exposed to damage by being stepped on. The weapon simulator **10** is much more adaptable to electronics because there is no space lost due to cartridges from the magazine **14** and through the weapon simulator **10** and because the gas flow is controlled by electric valves **20, 22**. Because there are fewer moving parts without cartridges and because the chambering, firing, ejecting and extracting functions do not have to be literally performed in the weapon simulator **10** for each shot, the simulator with the present gas system is more reliable both per-shot and over-all.

[0032] The third gas system also has limitations are solved by the present design. In particular, with the present invention, recharging occurs only once for each time that a real weapon magazine would be reloaded. Since magazines can typically hold from eight to thirty cartridges, this saves numerous rechargings per magazine **14** used. In addition, no cartridges need to be loaded into the magazine **14** of the present invention. Therefore, this weapon simulator **10** is much easier to use. As discussed above, since no cartridges are expelled, there is no "clean-up" necessary for the user. Moreover, the gas system **12** is much more adaptable for use with electronics because there is no space lost due to cartridges from the magazine and through the weapon, and also because the gas flow is controlled by electric valves **20, 22**. Because there are fewer moving parts without cartridges and because the chambering, firing, ejecting and extracting functions do not have to be literally performed in the weapon for each shot, the simulator with this gas system **12** is more reliable both per-shot and over-all.

[0033] Another embodiment of the invention is illustrated in Figures 2 through 4. In this embodiment, a low-pressure gas supply **40** is used in the weapon simulator **10** in conjunction with a small, low-pressure, electrically operated pilot valve (not illustrated) that drives a larger, operated pilot valve **44**. The weapon simulator **10** includes a firearm housing **11** or frame, with a cylinder and piston assembly having a piston **58** positioned in a piston chamber

59 contained within the firearm housing **11**. The pilot valve **44** furthermore drives the piston assembly as desired. This arrangement allows the use of very small, low-pressure electrically operated pilot valve **44**, while still providing sufficient flow for adequate recoil to accurately simulate the operation of a firearm. It should be noted that the pilot valve **44** is connected to the gas supply **40**, and also to the valve chamber **47** by pilot channel **50**.

[0034] In particular, the low-pressure gas supply **40** is fed to both a distal end **46a** of a recoil valve **46** and the pilot valve **44** via gas supply channel **42**. The recoil valve **46** preferably includes four valve gates **62** or flanges, and the recoil valve **46** is slidably positioned in the valve cavity **47** with the valve gates **62** abutting the walls of the valve cavity **47**. The valve gates **62** further define a series of valve cavities: a distal valve cavity **64a**, a central valve cavity **64b**, and a proximal valve cavity **64c**. Gasses thereby traverse the valve cavities **64a**, **64b**, and **64c** as required for proper operation. Furthermore, a spring **48** or other biasing means is positioned in the valve cavity **47** to apply pressure to a proximal end **46b** of the recoil valve **46**.

[0035] While the weapon simulator **10** is not being fired, the recoil valve **46** will remain in the position shown in Figure 2. That is, the recoil valve **46** is held by the spring **48** in the non-triggered position in the valve cavity **47**. In this position, the recoil cylinder port **52** is connected to the exhaust port **54** through the central valve gap **64b**, such that no pressure is applied to the cylinder and piston assembly **58**. However, when an electrical signal opens the pilot valve **44**, a low-pressure gas is fed to the pilot channel **50** to apply pressure to the distal end **46a** of the recoil valve **46**. As pressure is applied to the distal end **46a** of the recoil valve **46**, the recoil valve **46** is shifted toward the spring **48** and overcomes the force of the spring **48**. As the recoil valve **46** moves, the distal valve gap **64a** is displaced to close the exhaust port **54**, and correspondingly the central valve gap **64b** moves to expose the pressure port **56** and a primary gas supply channel **42**. Thus, compressed gas from the gas supply **40** flows

through the primary gas supply channel **42** through central valve gap **64b** and into cylinder port **52**. This compressed gas is thereby directed into the piston chamber **59** to force the piston **58**, and thus the attached bolt **60** as well, toward the user. As a result, the desired recoil of the bolt **60** is generated.

[0036] After firing, the pilot valve **44** is then again closed, such that the spring **48** will overcome the force applied on the recoil valve **46**. Consequently, the recoil valve **46** will once again move into position wherein the gas supply channel **42** is directed into proximal valve gap **64c** and thus closed and the central valve gap **64b** adjoins the exhaust port **54** to discharge and equalize the weapon simulator **10**. The remainder of the weapon simulator **10** further returns to the desired resting position to await activation of the pilot valve **44** once again. Once in the resting position, the weapon simulator **10** waits for the next firing situation by the user.

[0037] Thus, although there have been described particular embodiments of the present invention of a new and useful GAS OPERATING SYSTEM FOR FIREARM SIMULATORS, it is not intended that such references be construed as limitations upon the scope of this invention except as set forth in the following claims.